Remarks

Support for the above-requested amendments to claim 1 is found at least in paragraphs [0025] and [0026]. Support for the amendments to claim 21 is found at least in paragraphs [0028] and [0030]. Claim 4 has been amended to recite a liquid sugar to correspond to claim 1. Claims 13-14, 22, and 26 have been canceled without prejudice. Claims 3, 9, 12, and 17-20 were canceled without prejudice in previous Amendments. New claims 27 and 28 are supported at least by paragraph [0027]. New claims 29 and 30 are supported at least by paragraph [0024]. Support for newly added claim 31 is found at least in paragraph [0024]. No question of new matter arises and entry of the amendments and new claims is respectfully requested.

Claims 1, 2, 4-8, 10-12, 15-16, 21, 23-24, and 27-31 are before the Examiner for consideration.

Formal Matter

As shown above, Applicant has added new claims 27-31 by amendment (*i.e.*, five claims). Because the total number of claims Applicant is submitting for examination (*i.e.*, twenty claims) is not greater than the total number of claims previously presented and paid for (*i.e.*, twenty claims), Applicant respectfully submits that no additional filing fees are required for newly added claims 27-31. Furthermore, because support for newly added claims 27-31 is found throughout the specification, as identified in the opening paragraph of the Remarks, Applicant respectfully submits that these newly added claims do not contain any new matter.

Rejection under 35 U.S.C. §112

Claims 11-16 and 26 have been rejected under 35 U.S.C. §112, second paragraph, as being indefinite. In particular, the Examiner asserts that claim 11 suggests that the sugar is melted after it has been applied to the internal walls of the preform mold, but claim 26 recites that the sugar is provided to the mold in melted or solution form. The Examiner further asserts that claims 13 and 26 render the intention of claim 11 unclear. Additionally, the Examiner asserts that claim 26 recites partially melting the sugar whereas claim 11 requires melting the sugar.

In response to the rejection of the remaining claims, Applicant has amended claim 11 to recite that the sugar is a molten sugar and has canceled claims 13-14 and 26 without

prejudice. Applicant submits that as amended, claims 11, 12, 15, and 16 are sufficiently definite and respectfully requests that the Examiner reconsider and withdraw this rejection.

Rejection under 35 U.S.C. §103(a)

The Examiner has rejected claims 1, 2, 4-6, 8-10, 21, 22, and 24 under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 5,766,541 to Knutsson, *et al.* ("Knutsson") in view of U.S. Patent No. 2,288,072 to Collins ("Collins"). The Examiner asserts that Knutsson teaches a method for making preforms from glass fiber strands where the glass fibers are texturized by separation to form a wool-type product prior to entry into the mold. The Examiner makes note that Knutsson makes reference by incorporation to U.S. Patent No. 4,569,471 to Ingemansson, *et al.* which assertedly teaches that the texturized wool fiber may travel through a hose prior to being fed into the mold. It is asserted that the binder, water, and glass fibers of Knutsson are fed into the mold and the mold is heated to cure the binder. The Examiner also asserts that Knutsson discloses that the binder preferably comprises about 2-10% by weight of the preform. The Examiner admits that Knutsson does not disclose that the binder is sugar in powdered or granulated form.

In this regard, Collins is cited for assertedly disclosing a method for making a fibrous product where a powdered sugar binder is disclosed. The Examiner concludes that it would have been obvious to one of skill in the art to have employed a powdered or granulated sugar binder as suggested by Collins as the binder in the method of Knutsson since Collins suggests that sugar is an art recognized equivalent alternative binder known in the art for glass wool applications.

In response to the rejection of claims 1, 2, 4-6, and 8-10, Applicant respectfully directs the Examiner's attention to the amendments made to independent claim 1 submits that claim 1, as amended, defines a method of forming a preform that is not taught or suggested within Knutsson and Collins, either alone or in combination.

In particular, Applicant respectfully submits that neither Knutsson nor Collins teaches or suggests the utilization of a liquid sugar binder as claimed in claim 1. With respect to Knutsson, Applicant submits that Knutsson is silent with respect to any teaching or suggestion of the use of a sugar binder. Indeed, it is submitted that Knutsson does not teach or suggest the use of sugar, as a binder or otherwise. Collins, on the other hand, discloses the use of "sugars" as potential binders. (*See, e.g.*, column 3, lines 48-53). As taught by the

Online Merriam Webster Dictionary, "sugar" is defined as "a class of edible crystalline substances including sucrose, lactose, and fructose (emphasis added)". (*See*, Attachment A, http://en.wikipedia.org/wiki/Sugar, attached hereto for the Examiner's convenience). Accordingly, Applicant respectfully submits that the "sugar" taught by Collins is a crystalline sugar, and is not a liquid sugar as claimed by amended claim 1. It is respectfully submitted that Collins further discloses the use of a non-liquid sugar binder at column 3, lines 56-59 where Collins teaches that dry binders such as sugars may be used in the air circulation system. Applicant therefore respectfully submits that the sugar binder disclosed in Collins is a crystalline or otherwise non-liquid sugar binder. Indeed, it is submitted that if Collins had intended a liquid sugar, the sugar would have been thus defined. It is therefore submitted that neither Knutsson nor Collins teaches or suggests the liquid sugar binder claimed in claim 1. In addition, Applicant respectfully submits that the combination of the teachings of Knutsson and Collins would not result in the method of forming a preform for a muffler as claimed in claim 1. Accordingly, it is respectfully submitted that the rejection of claim 1 must fail.

Additionally, Applicant submits that Knutsson specifically teaches the utilization of a powdered binder. (*See, e.g.*, column 1, lines 62-63; column 3, lines 59-61; and column 8, lines 50-51). Applicant therefore submits that one of skill in the art reading Knutsson would have no motivation to look elsewhere for a non-powdered binder.

Further, Applicant respectfully submits that the method of Knutsson would destroy a sugar binder. Knutsson teaches heating the mold to a curing temperature, which, Applicant submits, is higher than the caramelization temperatures of sugars. Applicant submits that a curing temperature would destroy the sugar binder and render it useless for its intended purpose. For example, Knutsson teaches heating the mold to a temperature to cure a non-sugar binder, *i.e.*, a phenolic binder, whose curing temperature is from about 300-400 °C (572-752 °F). Such temperatures are well beyond the caramelization temperatures of sugars. Thus, it is respectfully submitted that if a sugar binder was used in Knutsson, the sugar binder would be destroyed by the high temperatures utilized by Knutsson and would render the binder useless for its intended purpose.

Assuming, *arguendo*, that one of skill in the art were to look to Collins for a suitable heating temperature, Collins teaches subjecting pyrolyzing heat to the binder-containing mat (*i.e.*, heating to a temperature from 700-800 °F (371-426 °C)). (*See, e.g.*, column 3, lines 43-62 and column 5, lines 7-17). It is submitted that such temperatures are far beyond the

caramelization temperature of sugars and would also destroy the sugar binder. As such, it is respectfully submitted that the combination of Knutsson and Collins would not result in the invention claimed in claim 1.

In addition, Applicant submits that there is no motivation for one of skill in the art to arrive at the method claimed in claim 1 based on the disclosure of Knutsson and/or Collins. To establish a *prima facie* case of obviousness, there must be some motivation, either within the reference or in the knowledge of those of skill in the art, to modify the reference or combine the references' teachings, there must be a reasonable expectation of success, and the prior art references must meet all of the claim limitations. (*See, e.g., Manual of Patent Examining Procedure*, Patent Publishing, LLC, Eighth Ed., Rev. 3, August 2005, §2142). It is respectfully submitted that one of ordinary skill in the art would not be motivated to arrive at a method of forming a preform for a muffler that utilizes a liquid sugar binder based on the teachings of Knutsson and Collins because neither Knutsson nor Collins teaches or suggests a liquid sugar binder. Without some teaching or suggestion, there can be no motivation, and without motivation, there can be no *prima facie* case of obviousness.

With respect to the rejection of claims 21, 22, and 24, Applicant respectfully submits that neither Knutsson nor Collins teaches or suggests (1) pre-heating a preform mold to a temperature above the melting point of a sugar to be applied thereto, (2) placing a dissolved sugar on internal walls of the preform mold prior to feeding glass fibers to the preform mold, where the heat from the preform mold removes water from the dissolved sugar and leaves the sugar adhered to the internal walls of the preform mold, (3) feeding the glass fibers into the preform mold, (4) heating the preform mold to a temperature sufficient to melt the sugar, where the melted sugar adheres to the glass fibers positioned adjacent to the internal walls of the preform, and (5) cooling the preform mold to bond glass fibers positioned adjacent to the internal walls of the preform mold together and form the preform where the bonded glass fibers form an encapsulating shell of glass fibers bonded by the sugar binder and the bonded glass fibers surround internal, unbonded glass fibers within the preform as claimed in amended claim 21.

As discussed in detail above, it is respectfully submitted that Knutsson and Collins do not teach or suggest a dissolved or "non-crystalline" sugar. According to the Online Merriam Webster Dictionary, the term "sugar" is defined as a class of crystalline substances. Therefore, Applicant respectfully submits that the "sugar" taught by Collins is a crystalline or

otherwise non-liquid sugar, and is not a dissolved sugar as required by amended claim 21. Knutsson does not teach or suggest the use of sugar, as a binder or otherwise. Accordingly, it is submitted that neither Knutsson nor Collins teaches or suggests the dissolved sugar binder as claimed in claim 21. Because Knutsson and Collins do not teach or suggest the utilization of a dissolved sugar as required by claim 21, Applicant submits that claim 21 is non-obvious and patentable.

In addition, Applicant respectfully submits that Knutsson and Collins do not teach or suggest pre-heating a preform mold or placing a dissolved sugar onto the internal walls of a preform mold where the heat from the pre-heated preform mold removes water from the dissolved sugar binder and leaves sugar adhered to the internal walls of the preform mold. Indeed, both Knutsson and Collins are silent with respect to any teaching or suggestion of any pre-heating of the preform mold or of placing a dissolved sugar binder on the internal walls of the preform mold. Also, there is no teaching or suggestion of a second heating step within Knutsson or Collins. Further, Knutsson and Collins do not teach or even suggest cooling the preform mold to bond glass fibers positioned adjacent to the internal walls of the preform mold together and form an encapsulating shell of bonded glass fibers.

Further, Applicant submits that there is no motivation for one of skill in the art to arrive at the method claimed in claim 21 based on the disclosure of Knutsson and/or Collins. As discussed above, to establish a *prima facie* case of obviousness, there must be some motivation, either within the reference or in the knowledge of those of skill in the art, to modify the reference or combine the references' teachings, there must be a reasonable expectation of success, and the prior art references must meet all of the claim limitations. (*See, e.g., Manual of Patent Examining Procedure*, Patent Publishing, LLC, Eighth Ed., Rev. 3, August 2005, §2142). It is respectfully submitted that one of ordinary skill in the art would not be motivated to arrive at the claimed method of forming a preform for a muffler based on the teachings of Knutsson and Collins because neither Knutsson nor Collins teaches or suggests a liquid sugar binder, pre-heating a preform mold, placing a dissolved sugar onto the internal walls of a preform mold, heating the preform mold a second time, or cooling the preform mold to bond glass fibers positioned adjacent to the internal walls of the preform mold together and form an encapsulating shell of glass fibers. Without some teaching or suggestion, there can be no motivation, and without motivation, there can be no *prima facie* case of obviousness.

In view of the above, Applicant respectfully submits that amended claims 1 and 21 are patentably distinguishable over Knutsson and Collins, either alone or in combination. Because claims 2, 4-6, 8-10 are dependent upon independent claim 1 and claims 22 and 24 are dependent upon claim 21, and because claims 1 and 21, as discussed above, are not taught or suggested within the Examiner's cited references, claims 2, 4-6, 8-10, 22, and 24 are also submitted to be non-obvious and patentable.

Accordingly, Applicant respectfully submits that claims 1-2, 4-6, 8-10, 21-22, and 24 are not obvious over Knutsson in view of Collins and respectfully requests that the Examiner reconsider and withdraw this rejection.

Rejection under 35 U.S.C. §103(a)

Claims 7 and 23 have been rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 5,766,541 to Knutsson, *et al.* ("Knutsson") in view of U.S. Patent No. 2,288,072 to Collins ("Collins") as applied to claims 1, 2, 4-6, 8-10, 21-22, and 24 above, and further in view of U.S. Patent No. 5,317,037 to Golden, *et al.* ("Golden"). The Examiner asserts that the combination of Knutsson and Collins does not expressly teach the melting point of the powdered sugar. In this regard, Golden is cited for teaching that sugars can be used as binders and that the sugars have a melting point in the range of 120 °C (248 °F) to 175 °C (347 °F). The Examiner asserts that it would have been obvious to one of skill in the art to employ a sugar such as sucrose, fructose, or dextrose as the sugar binder in the method of Knutsson for the purpose of employing readily available and well-known sugars as effective binders.

In response to this rejection, Applicant respectfully directs the Examiner's attention to the amendments made to independent claims 1 and 21 and to the arguments set forth above with respect to the rejection of claims 1, 2, 4-6, 8-10, 21, 22, and 24 under 35 U.S.C. §103(a) to Knutsson in view of Collins and submits that claims 1 and 21, as amended, define methods of forming preforms that are not taught or suggested within Knutsson and Collins, either alone or in combination. As discussed above, Knutsson and Collins do not teach or suggest methods for forming muffler preforms that utilize a liquid sugar and a dissolved sugar binder, respectively. Further, it is submitted that Knutsson and Collins do not teach or suggest pre-heating a preform mold, placing a dissolved sugar on the internal walls of a preform mold, heating the preform mold a second time, or cooling the preform mold to bond glass fibers

positioned adjacent to the internal walls of the preform mold together and form an encapsulating shell of glass fibers as is required by amended claim 21.

Golden teaches the use of a sugar such as sucrose, dextrose, or fructose as a binder. (*See, e.g.*, column 2, lines 56-60). As discussed previously, the online Merriam Webster Dictionary defines "sugar" as a crystalline substance. Accordingly, it is respectfully submitted that Golden does not teach or suggest either a liquid or dissolved sugar as claimed in claims 1 and 21. Furthermore, Golden does not teach or suggest placing a dissolved sugar on the internal walls of a preform mold, pre-heating the preform mold, heating the preform mold a second time, or cooling the preform mold to bond the glass fibers positioned adjacent to the internal walls of the preform mold together and form an encapsulating shell as claimed in claim 21. As a result, Golden does not make up for the deficiencies of Knutsson and Collins. Therefore, it is respectfully submitted that claims 1 and 21, as amended, are not taught or suggested by Knutsson, Collins, and/or Golden. As such, Applicant respectfully submits that claims 1 and 21 are non-obvious and patentable over Knutsson, Collins, and Golden, in any combination. Because claims 7 and 23 are dependent upon claim 1 and claim 21, respectively, which, as discussed above, are neither taught nor suggested by Knutsson and Collins, and because Golden adds nothing to the teachings of Knutsson or Collins with respect to teaching a liquid or dissolved sugar, placing a liquid sugar onto the internal walls of a preform mold, pre-heating the preform mold, heating the preform mold after feeding the glass fibers to the preform mold, or cooling the mold to bond the glass fibers adjacent to the internal walls of the preform mold together and form an encapsulating shell, Applicants submit that claims 7 and 23 are not taught or suggested by the combination of Knutsson, Collins, and/or Golden.

Applicant respectfully submits that because claim 7 depends from claim 1 and claim 23 depends from claim 21, and because claims 1 and 23 are not taught or suggested by the combination of Knutsson, Collins, and Golden as discussed above, Applicant submits that claims 7 and 23 are also not taught or suggested by Knutsson, Collins, and Golden, in any combination.

In light of the above, Applicant submits that claims 7 and 23 are non-obvious and patentable and respectfully request that this rejection be reconsidered and withdrawn.

Rejection under 35 U.S.C. §103(a)

Claims 11-16 have been rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 4,751,134 to Chenoweth, *et al.* ("Chenoweth") in view of U.S. Patent No. 6,319,444 to Kirk ("Kirk") and U.S. Patent No. 4,210,230 to Tyhurst ("Tyhurst"), and further in view of U.S. Patent No. 2,288,072 to Collins ("Collins") and U.S. Patent No. 5,317,037 to Golden, *et al.* ("Golden"). The Examiner asserts that Chenoweth teaches a method of making a non-woven matrix of glass fibers and synthetic fibers where, when activated by heat, the matrix is controlled such that only selected fibers are bonded to each other. For example, the fibers adjacent to one or both faces of the matrix may be bonded to each other, thereby leaving other fibers unbonded. Additionally, it is asserted that Chenoweth teaches that an imperforate film or skin layer may be applied to the surfaces of the matrix/blanket to provide a smooth surface for the product. However, the Examiner admits that Chenoweth does not teach the employment of continuous glass fibers or how the skin layer is formed.

Kirk is cited for teaching that continuous glass fibers provide advantages of improved strength, higher service temperature, and lower levels of required binder than discrete length glass fibers. It is also asserted that Kirk teaches employing a heated mold to shape the product as desired.

Tyhurst teaches a method of forming a fiber-reinforced article with a skin layer/gel coating where a binder is placed on the internal wall of a mold prior to placing glass fibers into the mold.

The Examiner concludes that it would have been obvious to one of skill in the art to have employed continuous glass fibers as suggested by Kirk in the method of Chenoweth and to have additionally formed the skin layer disclosed by Chenoweth by the method taught by Tyhurst for the purpose of realizing the advantages of continuous glass fibers disclosed by Kirk and to have effectively formed the skin layer with a smooth finish on all exposed surfaces as suggest by Tyhurst.

The Examiner also admits that Chenoweth does not teach that the skin layer binder is a sugar as claimed. In this regard, Collins is cited for assertedly teaching a method for making a fibrous product from glass wool fibers where a powder binder is utilized. In addition, the Examiner asserts that Golden provides evidence that sugars are known to be suitable binders. The Examiner concludes that it would have been obvious to one of skill in the art to have employed sugar as the binder for forming the skin layer in the method

disclosed by Chenoweth since Collins suggests that sugar is an art recognized equivalent alternative binder for glass wool applications and Golden discloses specific sugars suitable for use as binders.

Initially, Applicant submits that claims 13-14 have been canceled without prejudice, thereby rendering the rejection of these claims moot.

In response to the rejection of the remaining claims, Applicant respectfully directs the Examiner's attention to the amendments made to independent claim 11 and submits that claim 11, as amended, defines a method of forming a preform that is not taught or suggested within Chenoweth, Kirk, Tyhurst, Collins, and Golden, either alone or in any combination.

Applicant submits that none of the Examiner's cited references teach or suggest the use of a molten sugar binder or placing a molten sugar binder on internal walls of a pre-heated preform mold prior to feeding continuous glass strands to the pre-heated preform mold as claimed in claim 11. Collins discloses the use of "sugars" as potential binders. (*See, e.g.*, column 3, lines 48-53). Golden teaches the use of a "sugar" such as sucrose, dextrose, or fructose as a binder. (*See, e.g.*, column 2, lines 56-60). As taught by the Online Merriam Webster Dictionary, "sugar" is defined as "a class of edible <u>crystalline</u> substances including sucrose, lactose, and fructose (emphasis added)". (*See*, Attachment A, <u>http://en.wikipedia.org/wiki/Sugar</u>, attached hereto for the Examiner's convenience). Indeed, Golden specifically teaches the use of sucrose and fructose, which are crystalline substances. Accordingly, Applicant respectfully submits that the "sugar" taught by Collins and Golden is a crystalline sugar, and is <u>not</u> a molten sugar as is required by amended claim 11. None of Chenoweth, Kirk, and Tyhurst teaches or suggests the use of a sugar binder. Indeed, Chenoweth, Kirk, and Tyhurst are silent with respect to any teaching regarding the use of a sugar in any capacity or in any form. Therefore, it is submitted that Chenoweth, Kirk, Tyhurst, Collins, and Golden do not teach or suggest the utilization of a molten sugar as required by claim 11. Accordingly, Applicant submits that claim 11 is non-obvious and patentable. In addition, Applicant respectfully submits that the combination of the teachings of Chenoweth, Kirk, Tyhurst, Collins, and Golden would not result in the method of forming a preform for a muffler as claimed in amended claim 11.

Additionally, Applicant submits that Chenoweth specifically teaches the utilization of thermosetting resin particles. (*See, e.g.*, column 4, lines 7-10). Applicant respectfully

submits that one of skill in the art reading Chenoweth would have no motivation to look elsewhere for a non-particle binder, such as the molten sugar binder of claim 11.

Further, Applicants submit that none of Chenoweth, Kirk, Tyhurst, Collins, or Golden teach or suggest pre-heating a preform mold to a temperature above the melting point of a sugar to be applied thereto as required by claim 11. Kirk discloses a process of placing continuous filament wool into a mold, adding a binder material to the filaments, and molding the continuous filament wool, but is silent as to any teaching or suggestion of pre-heating the mold prior to placing the wool into the mold. (*See, e.g.*, column 4, lines 9-16). Tyhurst teaches the application of a thermosetting plastic material to mold surfaces, but, as with Kirk, fails to teach or suggest pre-heating the mold. (*See, e.g.*, column 3, lines 16-19). As claimed in amended claim 11, the pre-heated preform mold maintains the molten sugar binder in its molten state. Such a feature is neither taught nor suggested by any of the Examiner's cited references. Accordingly, Applicant respectfully submits that the combination of the teachings of Chenoweth, Kirk, Tyhurst, Collins, and Golden would not result in the method of forming a preform for a muffler as claimed in claim 11. Accordingly, it is respectfully submitted that claim 11 is non-obvious and patentable.

In addition, Applicant submits that there is no motivation for one of skill in the art to arrive at the invention claimed in claim 11 based on the disclosures of Chenoweth, Kirk, Tyhurst, Collins, and/or Golden. To establish a *prima facie* case of obviousness, there must be some motivation, either within the reference or in the knowledge of those of skill in the art, to modify the reference or combine the references' teachings, there must be a reasonable expectation of success, and the prior art references must meet all of the claim limitations. (*See, e.g., Manual of Patent Examining Procedure*, Patent Publishing, LLC, Eighth Ed., Rev. 3, August 2005, §2142). It is respectfully submitted that one of ordinary skill in the art would not be motivated to arrive at a method of forming a preform for a muffler that utilizes a molten sugar binder based on the teachings of Chenoweth, Kirk, Tyhurst, Collins, and Golden because none of Chenoweth, Kirk, Tyhurst, Collins, or Golden teach or even suggest a molten sugar binder. Additionally, none of the Examiner's cited references teach or suggest pre-heating a preform mold to maintain the molten sugar in its molten state on the internal walls of the pre-heated preform mold. Without some teaching or suggestion, there can be no motivation, and without motivation, there can be no *prima facie* case of obviousness.

In view of the above, Applicant respectfully submits that amended claim 11 is patentably distinguishable over Chenoweth, Kirk, Tyhurst, Collins, and Golden, either alone or in any combination. Because claims 12 and 15-16 are dependent upon independent claim 11, which, as discussed above, is not taught or suggested within Chenoweth, Kirk, Tyhurst, Collins, and Golden, claims 12 and 15-16 are also submitted to be non-obvious and patentable.

Applicant therefore respectfully submits that claims 11-12 and 15-16 are not obvious over Chenoweth in view of Kirk and Tyhurst and further in view of Collins and Golden and respectfully requests reconsideration and withdrawal of this rejection.

Rejection under 35 U.S.C. §103(a)

The Examiner has rejected claims 11-16 and 26 under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 4,751,134 to Chenoweth, *et al.* ("Chenoweth") in view of U.S. Patent No. 6,319,444 to Kirk ("Kirk") and U.S. Patent No. 4,210,230 to Tyhurst ("Tyhurst") and further in view of U.S. Patent No. 6,254,810 to Delvaux, *et al.* ("Delvaux") and U.S. Patent No. 6,800,364 to Chiu, *et al.* ("Chiu"). The Examiner asserts that Chenoweth teaches a method of making a non-woven matrix of glass fibers and synthetic fibers where the activation of the binder is controlled such that only selected fibers are bonded to one another and others remain unbonded. It is also asserted that Chenoweth teaches that an imperforate film or skin layer may be applied to the surfaces of the matrix/blanket to provide a smooth surface to the product. The Examiner admits that Chenoweth fails to teach the employment of continuous glass fibers or a detailed explanation on how the skin is formed.

Kirk is cited for assertedly teaching that in forming products from glass wool fibers, continuous glass fibers provide advantages of improved strength, higher service temperature, and lower levels of required binder than discrete glass fibers. It is asserted that Tyhurst teaches a method of forming a fiber-reinforced article with a skin layer/gel coating where a binder is placed on the internal wall of a mold prior to placing the glass fibers in the mold. The Examiner concludes that it would have been obvious to one of skill in the art to have employed continuous glass fibers as suggested by Kirk in the method of Chenoweth and to have additionally formed the skin layer disclosed by Chenoweth by the method disclosed by Tyhurst for the purpose of realizing the advantages provided by continuous glass fibers and to have effectively formed the skin layer with a smooth finish as taught by Tyhurst.

The Examiner also admits that Chenoweth does not teach or suggest that the skin layer binder is a sugar as claimed. In this regard, Chiu is cited for assertedly teaching the employment of a sucrose solution binder. Delvaux is cited for teaching a strong protective coating for a fabric made of glass fibers where the protective coating contains sugar. The Examiner concludes that it would have been obvious to one of skill in the art to have employed a sugar solution such as a sucrose solution as suggested by Chiu and Delvaux in the method of Chenoweth to provide an excellent protective cover for the fabric.

Initially, Applicant submits that claims 13-14 and 26 have been canceled without prejudice, thereby rendering the rejection of these claims moot.

In response to the rejection of the remaining claims, Applicant respectfully directs the Examiner's attention to independent claim 11 and to the arguments set forth above with respect to the rejection of claims 11-16 under 35 U.S.C. §103(a) to Chenoweth in view of Kirk and Tyhurst, and further in view of Collins and Golden and submits that claim 11 defines a method of forming a preform that is not taught or suggested within Chenoweth, Kirk, or Tyhurst, (and/or Collins and/or Golden), alone or in combination. In addition, Applicant submits that the teachings of Chiu and Delvaux fail to make up for the deficiencies of the combination of Chenoweth, Kirk, or Tyhurst, namely, teaching the utilization of a molten sugar and pre-heating a preform mold to a temperature above the melting point of a sugar to be applied thereto. Chiu and Delvaux both teach the use of a sugar solution, which is vastly different than a molten sugar as required by amended claim 11. Indeed, it is submitted that Chiu and Delvaux teach away from the use of a molten sugar. Additionally, Applicant submits that Chiu and Delvaux are silent with respect to any teaching or suggestion of pre-heating a preform mold to maintain the molten sugar in its molten state on the internal walls of the preform mold as claimed in amended claim 11. Accordingly, it is respectfully submitted that the combination of Chenoweth, Kirk, Tyhurst, Chiu, and Delvaux does not teach or suggest Applicant's process as claimed in claim 11. Because claims 12 and 15-16 are dependent upon claim 11, which, as discussed above, is not taught or suggested by Chenoweth, Kirk, Tyhurst, Chiu, and/or Delvaux, Applicant submits that claims 12 and 15-16, are also not taught or suggested by Chenoweth, Kirk, Tyhurst, Chiu, and/or Delvaux.

Additionally, Applicant submits that there is no motivation for one of skill in the art to arrive at the presently claimed invention based on the disclosures of Chenoweth, Kirk, Tyhurst, Chiu, and/or Delvaux. As discussed above, in order to establish a *prima facie* case

of obviousness, there must be some motivation to modify the reference or combine the references' teachings. (*See, e.g., Manual of Patent Examining Procedure*, Patent Publishing, LLC, Eighth Ed., Rev. 3, August 2005, §2142). It is respectfully submitted that one of ordinary skill in the art would not be motivated to arrive at the presently claimed process that includes pre-heating a preform mold to a temperature above the melting point of a sugar to be applied thereto based on the Examiner's combination of Chenoweth, Kirk, Tyhurst, Chiu, and/or Delvaux. Also, as discussed *supra*, Delvaux and Chiu fail to make up for the deficiencies of the cited prior art with respect to the feature of pre-heating a preform mold to maintain the molten sugar in its molten state on the internal walls of the preform mold. Further, none of the cited references teach or even suggest the utilization of a molten sugar binder. Without some teaching or suggestion, there can be no motivation, and without motivation, there can be no *prima facie* case of obviousness.

In view of the above, Applicant respectfully submits that claims 11-12 and 15-16 are non-obvious and patentable over the combination of the Examiner's cited references and respectfully requests that this rejection be reconsidered and withdrawn.

Rejection under 35 U.S.C. §103(a)

Claims 11-16 have been rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 4,846,302 to Hetherington ("Hetherington") in view of U.S. Patent No. 6,319,444 to Kirk ("Kirk") and U.S. Patent No. 3,812,074 to Oswitch, *et al.* ("Oswitch"), and further in view of U.S. Patent No. 2,288,072 to Collins ("Collins") and U.S. Patent No. 5,317,037 to Golden, *et al.* ("Golden"). The Examiner asserts that Hetherington teaches a method of forming a muffler where a binder-hardened outer shell surrounds a soft fibrous core. It is asserted that the binder-hardened outer shell is formed by bringing the outer portion of the fibrous glass into contact with a binder and then molding the fibers into the desired shape. The Examiner admits that Hetherington does not teach that the glass fibers are continuous or that the binder-hardened outer shell is formed by placing the binder on the internal wall of the preform mold prior to feeding the fibrous glass to the mold.

In this regard, Kirk is cited for assertedly teaching that continuous glass fibers provide advantages of improved strength, higher service temperature, and lower levels of required binder than discrete length glass fibers. Kirk also assertedly teaches a heated mold to shape the product as desired. Oswitch is cited for teaching a method of providing a hardened gel

coating around the exterior of a fiber glass article by placing the binder, in the form of a pre-fabricated gel coat, on the internal wall of the preform mold prior to feeding the fibrous glass into the mold.

The Examiner concludes that it would have been obvious to one of skill in the art to have employed continuous glass fibers as suggested by Kirk in the method disclosed by Hetherington and to have formed the hardened outer shell by the method disclosed by Oswitch for the purpose of realizing the advantages of continuous glass fibers disclosed by Kirk and to have effectively formed the hardened outer shell in the art recognized equivalent alternative method as suggested by Oswitch.

The Examiner also admits that Hetherington does not teach that the skin layer binder is a sugar as claimed. In this regard, Collins is cited for assertedly teaching a method for making a fibrous product from glass wool fibers where a powder binder is utilized. In addition, the Examiner asserts that Golden provides evidence that sugars are known to be suitable binders. Thus, the Examiner concludes that it would have been obvious to one of skill in the art to have employed sugar as the binder for forming the skin layer in the method disclosed by Chenoweth since Collins suggests that sugar is an art recognized equivalent alternative binder for glass wool applications and Golden discloses specific sugars suitable for use as binders.

Initially, Applicant submits that claims 13-14 have been canceled without prejudice, thereby rendering the rejection of these claims moot.

In response to the rejection of the remaining claims, Applicant respectfully directs the Examiner's attention to the amendments made to independent claim 11 and submits that claim 11, as amended, defines a method of forming a preform that is not taught or suggested within Hetherington, Kirk, Oswitch, Collins, and Golden, alone or in any combination.

Applicant submits that none of the Examiner's cited references teach or suggest the use of a molten sugar binder on internal walls of a pre-heated preform mold prior to feeding one or more continuous strands of glass fibers to the pre-heated preform mold as claimed in claim 11. Collins teaches "sugars" as potential binders. (*See, e.g.*, column 3, lines 48-53). Golden teaches the use of a "sugar" such as sucrose, dextrose, or fructose. (*See, e.g.*, column 2, lines 56-60). As taught by the Online Merriam Webster Dictionary, "sugar" is defined as "a class of edible crystalline substances including sucrose, lactose, and fructose (emphasis added)". (*See*, Attachment A, http://en.wikipedia.org/wiki/Sugar, attached hereto for the

Examiner's convenience). Indeed, Golden specifically teaches the use of sucrose and fructose, crystalline substances. Accordingly, Applicant respectfully submits that the "sugar" taught by both Collins and Golden is a crystalline sugar, and is not a molten sugar as is required by amended claim 11. None of Hetherington, Kirk, or Oswitch teaches or suggests the use of a sugar binder. Indeed, Hetherington, Kirk, or Oswitch are silent with respect to the use of a sugar in any capacity or in any form. Therefore, it is submitted that Hetherington, Kirk, Oswitch, Collins, and Golden do not teach or even suggest the utilization of a molten sugar as required by claim 11. Accordingly, Applicant submits that claim 11 is non-obvious and patentable.

Additionally, Applicant submits that none of Hetherington, Kirk, Oswitch, Collins, or Golden teaches or suggests pre-heating a preform mold to a temperature above the melting point of a sugar to be applied thereto. Kirk discloses a process of placing continuous filament wool into a mold, adding a binder material to the filaments, and molding the continuous filament wool, but is silent as to any teaching or suggestion of pre-heating the mold prior to placing the fibers into the mold. (*See, e.g.*, column 4, lines 9-16). Oswitch teaches the application of a dry, pre-fabricated gel coat and subsequent heating of the mold. (*See, e.g.*, column 4, lines 24-55). As claimed in amended claim 11, the pre-heated mold maintains the molten sugar binder in its molten state. Such a feature is not taught or even suggested by any of the Examiner's cited references. Accordingly, Applicant respectfully submits that the combination of the teachings of Hetherington, Kirk, Oswitch, Collins, and Golden would not result in the method of forming a preform as claimed in claim 11. Accordingly, it is respectfully submitted that the rejection of claim 11 must fail.

In addition, Applicant submits that there is no motivation for one of skill in the art to arrive at the invention claimed in claim 11 based on the disclosures of Hetherington, Kirk, Oswitch, Collins, and/or Golden. As discussed previously, to establish a *prima facie* case of obviousness, there must be some motivation, either within the reference or in the knowledge of those of skill in the art, to modify the reference or combine the references' teachings, there must be a reasonable expectation of success, and the prior art references must meet all of the claim limitations. (*See, e.g., Manual of Patent Examining Procedure*, Patent Publishing, LLC, Eighth Ed., Rev. 3, August 2005, §2142). It is respectfully submitted that one of ordinary skill in the art would not be motivated to arrive at a method of forming a preform that utilizes a molten sugar binder based on the teachings of Hetherington, Kirk, Oswitch,

Collins, and Golden because none of Hetherington, Kirk, Oswitch, Collins, or Golden teach or suggest a molten sugar binder. Additionally, none of the Examiner's cited references teach or suggest pre-heating a preform mold to maintain the molten sugar in its molten state on the internal walls of the preform mold. Without some teaching or suggestion, there can be no motivation, and without motivation, there can be no *prima facie* case of obviousness.

In view of the above, Applicant respectfully submits that amended claim 11 is patentably distinguishable over Hetherington, Kirk, Oswitch, Collins, and Golden, either alone or in any combination. Because claims 12 and 15-16 are dependent upon independent claim 11, which, as discussed above, is not taught or suggested within Hetherington, Kirk, Oswitch, Collins, and Golden, claims 12 and 15-16 are also submitted to be non-obvious and patentable.

Applicant therefore respectfully submits that claims 11-12 and 15-16 are not obvious over Hetherington in view of Kirk and Oswitch, and further in view of Collins and Golden and respectfully request reconsideration and withdrawal of this rejection.

<u>Rejection under 35 U.S.C. §103(a)</u>

Claims 11-16 and 26 have been rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 4,846,302 to Hetherington ("Hetherington") in view of U.S. Patent No. 6,319,444 to Kirk ("Kirk") and U.S. Patent No. 3,812,074 to Oswitch, *et al.* ("Oswitch"), and further in view of U.S. Patent No. 6,254,810 to Delvaux, *et al.* ("Delvaux") and U.S. Patent No. 6,800,364 to Chiu, *et al.* ("Chiu"). The Examiner asserts that Hetherington teaches a method of forming a muffler where a binder-hardened outer shell surrounds a soft fibrous core. It is asserted that the binder-hardened outer shell is formed by bringing the outer portion of the fibrous glass into contact with a binder and then molding the fibers into the desired shape. The Examiner admits that Hetherington does not teach that the glass fibers are continuous or that the binder-hardened outer shell is formed by placing the binder on the internal wall of the preform mold prior to feeding the fibrous glass into the mold.

In this regard, Kirk is cited for assertedly teaching that continuous glass fibers provide advantages of improved strength, higher service temperature, and lower levels of required binder than discrete length glass fibers. Kirk also assertedly teaches a heated mold to shape the product as desired. Oswitch is cited for teaching a method of providing a hardened gel

coating around the exterior of a fiber glass article by placing the binder, in the form of a pre-fabricated gel coat, on the internal wall of the preform mold prior to feeding the fibrous glass into the mold.

The Examiner concludes that it would have been obvious to one of skill in the art to have employed continuous glass fibers as suggested by Kirk in the method disclosed by Hetherington and to have formed the hardened outer shell by the method disclosed by Oswitch for the purpose of realizing the advantages of continuous glass fibers as disclosed by Kirk and to have effectively formed the hardened outer shell in the art recognized equivalent alternative method as suggested by Oswitch.

The Examiner also admits that Hetherington does not teach or suggest that the skin layer binder is a sugar as claimed. In this regard, Chiu is cited for assertedly teaching the employment of a sucrose solution binder. Delvaux is cited for teaching a strong protective coating for a fabric made of glass fibers where the protective coating contains sugar. The Examiner concludes that it would have been obvious to one of skill in the art to have employed a sugar solution such as a sucrose solution as suggested by Chiu and Delvaux in the method of Hetherington to provide an excellent protective cover for the fabric.

Initially, Applicant submits that claims 13-14 and 26 have been canceled without prejudice, thereby rendering the rejection of these claims moot.

In response to the rejection of the remaining claims, Applicant respectfully directs the Examiner's attention to independent claim 11 and to the arguments set forth above with respect to the rejection of claims 11-16 under 35 U.S.C. §103(a) to Hetherington in view of Kirk and Oswitch, and further in view of Collins and Golden and submits that claim 11 defines a method of forming a preform that is not taught or suggested within Hetherington, Kirk, or Oswitch, (and/or Collins and/or Golden), alone or in combination. In addition, Applicant submits that the teachings of Chiu and Delvaux fail to make up for the deficiencies of the combination of Hetherington, Kirk, and Oswitch, namely, teaching the utilization of a molten sugar and pre-heating a preform mold to a temperature above the melting point of a sugar to be applied thereto. Chiu and Delvaux both teach the use of a sugar solution, which is vastly different than a molten sugar as is required by amended claim 11. Indeed, it is submitted that Chiu and Delvaux teach away from the use of a molten sugar. Additionally, Applicant submits that Chiu and Delvaux are silent with respect to any teaching or suggestion of pre-heating a preform mold to maintain the molten sugar in its molten state on the internal

walls of the preform mold. Accordingly, it is respectfully submitted that the combination of Hetherington, Kirk, Oswitch, Chiu, and Delvaux does not teach or suggest Applicant's process as claimed in amended claim 11. Because claims 12 and 15-16 are dependent upon claim 11, which, as discussed above, is not taught or suggested by Hetherington, Kirk, Oswitch, Chiu, and/or Delvaux, Applicant submits that claims 12 and 15-16 are also not taught or suggested by Hetherington, Kirk, Oswitch, Chiu, and/or Delvaux.

Additionally, Applicant submits that there is no motivation for one of skill in the art to arrive at the presently claimed invention based on the disclosures of Hetherington, Kirk, Oswitch, Chiu, and/or Delvaux. As discussed above, in order to establish a *prima facie* case of obviousness, there must be some motivation to modify the reference or combine the references' teachings. (*See, e.g., Manual of Patent Examining Procedure*, Patent Publishing, LLC, Eighth Ed., Rev. 3, August 2005, §2142). It is respectfully submitted that one of ordinary skill in the art would not be motivated to arrive at the presently claimed process that includes pre-heating a preform mold to a temperature above the melting point of a sugar to be applied thereto based on the Examiner's combination of Hetherington, Kirk, Oswitch, Chiu, and/or Delvaux. As discussed *supra*, Delvaux and Chiu do not make up for the deficiencies of the cited prior art with respect to the feature of pre-heating a preform mold to maintain the molten sugar in its molten state on the internal walls of the preform mold. Further, none of the cited references teach or even suggest the utilization of a molten sugar binder. Without some teaching or suggestion, there can be no motivation, and without motivation, there can be no *prima facie* case of obviousness.

In view of the above, Applicant respectfully submits that claims 11-12 and 15-16 are non-obvious and patentable over the combination Hetherington, Kirk, Oswitch, Chiu, and Delvaux and respectfully requests reconsideration and withdrawal of this rejection.

Conclusion

In light of the above, Applicant believes that this application is now in condition for allowance and therefore requests favorable consideration.

If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

If necessary, the Commissioner is hereby authorized to charge payment or credit any overpayment to Deposit Account No. 50-0568 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

Date: 4/1/08

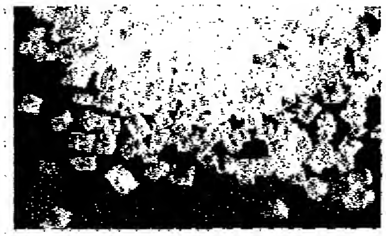
Margaret S. Millikin
Registration No. 38,969

Owens Corning
Patent Department, Bldg. 21-0
2790 Columbus Road
Granville, Ohio 43023
(740) 321-5359

Sugar

From Wikipedia, the free encyclopedia

Sugar (the word stems from the Sanskrit *sharkara*) consists of a class of edible crystalline substances including sucrose, lactose, and fructose. Human taste-buds interpret its flavor as sweet. Sugar as a basic food carbohydrate primarily comes from sugar cane and from sugar beet, but also appears in fruit, honey, sorghum, sugar maple (in maple syrup), and in many other sources. It forms the main ingredient in much candy. Excessive consumption of sugar has been associated with increased incidences of type-2 diabetes, obesity and tooth-decay.



Magnification of grains of sugar, showing their monoclinic hemihedral crystalline structure.

Contents

- 1 Terminology
  - 1.1 Popular
  - 1.2 Scientific
  - 1.3 Culinary/nutritional
- 2 History
  - 2.1 Early use of sugar-cane in Asia
  - 2.2 Cane sugar outside Asia
  - 2.3 The rise of beet sugar
  - 2.4 Mechanization
- 3 Etymology
- 4 As a food
- 5 Human health
  - 5.1 Tooth-decay
  - 5.2 Diabetes
  - 5.3 Obesity
  - 5.4 Gout
  - 5.5 United Nations nutritional advice
  - 5.6 Debate on extrinsic sugar
  - 5.7 Concerns of vegetarians and vegans
- 6 Production
  - 6.1 Cane
  - 6.2 Beet
  - 6.3 Cane versus beet
  - 6.4 Culinary sugars
- 7 Chemistry
- 8 Measuring sugar
  - 8.1 Dissolved sugar content
  - 8.2 Purity
  - 8.3 Baking weight/mass volume relationship
- 9 Trade and economics
- 10 See also
- 11 Notes
- 12 References
- 13 External links

Sugar, granulated
Nutritional value per 100 g (3.5 oz)
Energy 390 kcal 1620 kJ

Carbohydrates	99.98 g
- Sugars 99.91 g	
- Dietary fiber 0 g	
Fat	0 g
Protein	0 g
Water	0.03 g
Riboflavin (Vit. B2) 0.019 mg	1%
Calcium 1 mg	0%
Iron 0.01 mg	0%
Potassium 2 mg	0%

Percentages are relative to US recommendations for adults.
Source: USDA Nutrient database

Sugars, brown
Nutritional value per 100 g (3.5 oz)
Energy 380 kcal 1580 kJ

Carbohydrates	97.33 g
- Sugars 96.21 g	
- Dietary fiber 0 g	
Fat	0 g
Protein	0 g
Water	1.77 g
Thiamin (Vit. B1) 0.008 mg	1%
Riboflavin (Vit. B2) 0.007 mg	0%
Niacin (Vit. B3) 0.082 mg	1%
Vitamin B6 0.026 mg	2%
Folate (Vit. B9) 1 μg	0%
Calcium 85 mg	9%
Iron 1.91 mg	15%
Magnesium 29 mg	8%
Phosphorus 22 mg	3%
Potassium 346 mg	7%
Sodium 39 mg	3%
Zinc 0.18 mg	2%

Percentages are relative to US recommendations for adults.
Source: USDA Nutrient database

Terminology

Popular

In non-scientific use, the term *sugar* refers to sucrose (also called "table sugar" or "saccharose") — a white crystalline solid disaccharide. In this informal sense, the word "sugar" principally refers to crystalline sugars.

Humans most commonly use sucrose as their sugar of choice for altering the flavor and properties (such as mouthfeel, preservation, and texture) of beverages and food. Commercially-produced table-sugar comes either from sugar cane or from sugar beet. Manufacturing and preparing food may involve other sugars, including palm sugar and fructose, generally obtained from corn (maize) or from fruit.

Sugar may dissolve in water to form a syrup. A great many foods exist which principally contain dissolved sugar. Generically known as "syrups", they may also have other more specific names such as "honey" or "molasses".

Scientific

Scientifically, *sugar* refers to any monosaccharide or disaccharide. Monosaccharides (also called "simple sugars"), such as glucose, store chemical energy which biological cells convert to other types of energy.

In a list of ingredients, any word that ends with "ose" will likely denote a sugar. Sometimes such words may also refer to any types of carbohydrates soluble in water.

Glucose (a type of sugar found in human blood-plasma) has the molecular formula $C_6 H_{12} O_6$.

Culinary/nutritional

In culinary terms, the foodstuff known as **sugar** delivers a primary taste sensation of sweetness. Apart from the many forms of sugar and of sugar-containing foodstuffs, alternative non-sugar-based sweeteners exist, and these particularly attract interest from people who have problems with their blood-sugar level (such as diabetics) and people who wish to limit their calorie-intake while still enjoying sweet foods. Both natural and synthetic substitutes exist with no significant carbohydrate (and thus low-calorie) content: for instance stevia (a herb), and saccharin (produced from naturally occurring but not necessarily naturally edible substances by inducing appropriate chemical reactions).

History

Early use of sugar-cane in Asia

Originally, people chewed the cane raw to extract its sweetness. Later, the Indians discovered how to crystallize sugar during the Gupta dynasty, around 350 AD.[1] John F. Robyt (1998) locates the two most probable origins of sugar cultivation as North East India or the South Pacific, which provide evidence of sugarcane cultivation as early as 10,000 BC and 6,000 BC respectively.[2] Further

archaeological evidence associates sugar with the Indus valley.[2]

This cultivation spread to the Indian subcontinent during early antiquity.[1] Sugar culture spread from India to China, and from China it spread even further.[2] However, sugar remained relatively unimportant until the Indians discovered methods of turning sugarcane juice into granulated crystals which would prove easier to store and to transport.[1] Indian sailors, consumers of clarified butter and sugar, spread this food through various trade routes.[1] In South Asia, the Middle East and China, sugar became a staple of cooking and desserts.

Some evidence suggests that the Greeks under Alexander the Great may have taken sugar from India during their retreat.[3] It would later spread to Europe and to Africa.[3]

Early refining methods involved grinding or pounding the cane in order to extract the juice, and then boiling down the juice or drying it in the sun to yield sugary solids that looked like gravel. The Sanskrit word for "sugar" (*sharkara*), also means "gravel". Similarly, the Chinese use the term "gravel sugar" (Traditional Chinese: □□) for table sugar.

Cane sugar outside Asia

A sugar-cane cutter in Cuba.

During the Muslim Agricultural Revolution, Arab entrepreneurs adopted the techniques of sugar production from India and then refined and transformed them into a large-scale industry. Arabs set up the first sugar mills, refineries, factories and plantations. The Arabs and Berbers diffused sugar throughout the Arab Empire and beyond across much of the Old World, including Western Europe after they conquered the Iberian Peninsula in the 8th century AD.[4] Crusaders also brought sugar home with them to Europe after their campaigns in the Holy Land, where they encountered caravans carrying "sweet salt". Crusade chronicler William of Tyre, writing in the late 12th century, described sugar as "very necessary for the use and health of mankind".

The 1390s saw the development of a better press, which doubled the juice obtained from the cane. This permitted economic expansion of sugar plantations to Andalucia and to the Algarve. The 1420s saw sugar-production extended to the Canary Islands, Madeira and the Azores.

In August 1492 Christopher Columbus stopped at Gomera in the Canary Islands, for wine and water, intending to stay only four days. He became romantically involved with the Governor of the island, Beatrice de Bobadilla, and stayed a month. When he finally sailed she gave him cuttings of sugar-cane, which became the first to reach the New World.

The Portuguese took sugar to Brazil. Hans Staden, published in 1555, writes that by 1540 Santa Catalina Island had 800 sugar-mills and that the north coast of Brazil, Demarara and Surinam had another 2000. Approximately 3000 small mills built before 1550 in the New World created an unprecedented demand for cast iron gears, levers, axles and other implements. Specialist trades in mold-making and iron-casting developed in Europe due to the expansion of sugar-production. Sugar-mill construction developed technological skills needed for a nascent industrial revolution in the early 17th-century.

After 1625 the Dutch carried sugar-cane from South America to the Caribbean islands — where it became grown from Barbados to the Virgin Islands. The years 1625 to 1750 saw sugar become worth its

weight in gold. Contemporaries often compared the worth of sugar with valuable commodities including musk, pearls, and spices. Prices declined slowly as production became multi-sourced, especially through British colonial policy. Formerly an indulgence of the rich, sugar became increasingly common among the poor. Sugar-production increased in mainland North American colonies, in Cuba, and in Brazil. African slaves became the dominant source of plantation-workers, as they proved resistant to the diseases of malaria and yellow fever. (European indentured servants remained in shorter supply, susceptible to disease and overall forming a less economic investment. European diseases such as smallpox had reduced the numbers of local Native Americans.) But replacement of Native American with African slaves also occurred because of the high death-rates on sugar-plantations. The British West Indies imported almost 4 million slaves, but had only 400,000 Blacks left after slavery ended in the British Empire in 1838.

With the European colonization of the Americas, the Caribbean became the world's largest source of sugar. These islands could supply sugar-cane using slave-labor and produce sugar at prices vastly lower than those of cane-sugar imported from the East. Thus the economies of entire islands such as Guadaloupe and Barbados became based on sugar-production. By 1750 the French colony known as Saint-Domingue (subsequently the independent country of Haiti) became the largest sugar-producer in the world. Jamaica too became a major producer in the 18th century. Sugar-plantations fueled a demand for manpower; between 1701 and 1810 ships brought nearly one million slaves to work in Jamaica and in Barbados.

During the eighteenth century, sugar became enormously popular and the sugar-market went through a series of booms. The heightened demand and production of sugar came about to a large extent due to a great change in the eating habits of many Europeans. For example, they began consuming jams, candy, tea, coffee, cocoa, processed foods, and other sweet victuals in much greater numbers. Reacting to this increasing craze, the islands took advantage of the situation and began producing more sugar. In fact, they produced up to ninety percent of the sugar that the western Europeans consumed. Some islands proved more successful than others when it came to producing the product. And in Barbados and the British Leeward Islands sugar provided 93% and 97% respectively of exports.

Planters later began developing ways to boost production even more. For example, they began using more manure when growing their crops. They also developed more advanced mills and began using better types of sugar-cane. Despite these and other improvements, the price of sugar reached soaring heights, especially during events such as the revolt against the Dutch and the Napoleonic Wars. Sugar remained in high demand, and the islands' planters knew exactly how to take advantage of the situation.

As Europeans established sugar-plantations on the larger Caribbean islands, prices fell, especially in Britain. By the eighteenth century all levels of society had become common consumers of the former luxury product. At first most sugar in Britain went into tea, but later confectionery and chocolates became extremely popular. Many Britons (especially children) also ate jams. Suppliers commonly sold sugar in solid cones and consumers required a sugar nip, a pliers-like tool, to break off pieces.

Sugar-cane quickly exhausts the soil in which it grows, and planters pressed larger islands with fresher soil into production in the nineteenth century. In this century, for example, Cuba rose to become the richest land in the Caribbean (with sugar as its dominant crop) because it formed the only major island land-mass free of mountainous terrain. Instead, nearly three-quarters of its land formed a rolling plain — ideal for planting crops. Cuba also prospered above other islands because Cubans used better methods when harvesting the sugar crops: they adopted modern milling-methods such as water-mills, enclosed

furnaces, steam-engines, and vacuum-pans. All these technologies increased productivity.

After the Haïtian Revolution established the independent state of Haiti, sugar production in that country declined and Cuba replaced Saint-Domingue as the world's largest producer.

Long established in Brazil, sugar-production spread to other parts of South America, as well as to newer European colonies in Africa and in the Pacific, where it became especially important in Fiji.

In Colombia, the planting of sugar started very early on, and entrepreneurs imported many African slaves to cultivate the fields. The industrialization of the Colombian industry started in 1901 with the establishment of the first steam-powered sugar mill by Santiago Eder.

While no longer grown by slaves, sugar from developing countries has an on-going association with workers earning minimal wages and living in extreme poverty.

The rise of beet sugar

In 1747 the German chemist Andreas Marggraf identified sucrose in beet-root. This discovery remained a mere curiosity for some time, but eventually Marggraf's student Franz Achard built a sugarbeet-processing factory at Cunern in Silesia (in present-day Poland), under the patronage of King Frederick William III of Prussia (reigned 1797 - 1840). While never profitable, this plant operated from 1801 until it suffered destruction during the Napoleonic Wars (ca 1802 - 1815).

Napoleon, cut off from Caribbean imports by a British blockade, and at any rate not wanting to fund British merchants, banned imports of sugar in 1813. The beet-sugar industry that emerged in consequence grew, and today sugar-beet provides approximately 30% of world sugar production.

In the developed countries, the sugar industry relies on machinery, with a low requirement for manpower. A large beet-refinery producing around 1,500 tonnes of sugar a day needs a permanent workforce of about 150 for 24-hour production.

Mechanization

Beginning in the late 18th century, the production of sugar became increasingly mechanized. The steam engine first powered a sugar-mill in Jamaica in 1768, and soon after, steam replaced direct firing as the source of process heat.

In 1813 the British chemist Edward Charles Howard invented a method of refining sugar that involved boiling the cane juice not in an open kettle, but in a closed vessel heated by steam and held under partial vacuum. At reduced pressure, water boils at a lower temperature, and this development both saved fuel and reduced the amount of sugar lost through caramelization. Further gains in fuel-efficiency came from the multiple-effect evaporator, designed by the African-American engineer Norbert Rillieux (perhaps as early as the 1820s, although the first working model dates from 1845). This system consisted of a series of vacuum pans, each held at a lower pressure than the previous one. The vapors from each pan served to heat the next, with minimal heat wasted. Today, many industries use multiple-effect evaporators for evaporating water.

The process of separating sugar from molasses also received mechanical attention: David Weston first applied the centrifuge to this task in Hawaii in 1852.

Etymology

In the case of sugar, the etymology reflects the spread of the commodity. The English word "sugar" originates from the Arabic and Persian word *shakar*,[5] itself derived from Sanskrit *Sharkara*.[4] It came to English by way of French, Spanish and/or Italian, which derived their word for sugar from the Arabic and Persian *shakar* (whence the Portuguese word *açúcar*, the Spanish word *azúcar*, the Italian word *zucchero*, the Old French word *zuchre* and the contemporary French word *sucre*). (Compare the OED.) The Greek word for "sugar", *zahari*, means "sugar" or "pebble". Note that the English word *jaggery* (meaning "coarse brown Indian sugar") has similar ultimate etymological origins (presumably in Sanskrit).

As a food

Originally a luxury, sugar eventually became sufficiently cheap and common to influence standard cuisine. Britain and the Caribbean islands have cuisines where the use of sugar became particularly prominent.

Sugar forms a major element in confectionery and in desserts. Cooks use it as a food preservative as well as for sweetening.

Human health

Some commentators have suggested links between sugar-consumption and health hazards, including obesity and tooth-decay.

Tooth-decay

Tooth-decay has arguably become the most prominent health-hazard associated with the consumption of sugar. Oral bacteria such as Streptococcus mutans live in dental plaque and metabolize sugars into lactic acid. High concentrations of acid may result on the surface of a tooth, leading to tooth demineralization.[6][7]

The American Dental Association sees tooth decay as caused "mostly" by starchy foods like breadsticks, cereals and potato-chips that linger on teeth and prolong acid-production, not by simple sugars that dissolve rapidly in the mouth.

Diabetes

Diabetes, a disease that causes the body to metabolize sugar poorly, occurs when either:

1. the body's cells ignore insulin, a chemical that allows the metabolizing of sugar (Type 2 diabetes)
2. the body attacks the cells producing the insulin (Type 1 diabetes)

When glucose builds up in the bloodstream, it can cause two problems:

1. in the short term, cells become starved for energy because they do not have access to the glucose

2. in the long term, frequent glucose build-up can damage many of the body's organs, including the eyes, kidneys, nerves and/or heart

Authorities advise diabetics to avoid sugar-rich foods to prevent adverse reactions.[8]

Obesity

In the United States of America, a scientific/health debate has started over the causes of a steep rise in obesity in the general population — and one view posits increased consumption of carbohydrates in recent decades as a major factor.[9]

Obesity can result from a number of factors including:

- an increased intake of energy-dense foods — high in fat and sugars but low in vitamins, minerals and other micronutrients (see United Nations advice below); and
- decreased physical activity.[10]

The National Health and Nutrition Examination Survey I and Continuous indicates that the population in the United States has increased its proportion of energy-consumption from carbohydrates and decreased its proportion from total fat while obesity has increased. This implies, along with the United Nations report cited below, that obesity may correlate better with sugar-consumption than with fat-consumption, and that reducing fat-consumption while increasing sugar-consumption actually increases the level of obesity. The following table summarizes this study (based on the proportion of energy-intake from different food sources for US Adults 20-74 years old, as carried out by the U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics, Hyattsville, MD[11]):

Year	Male/Female	Carbohydrate	Fat	Protein	Obesity
1971	Male	42.4%	36.9%	16.5%	12.1%
1971	Female	45.4%	36.1%	16.9%	16.6%
2000	Male	49.0%	32.8%	15.5%	27.7%
2000	Female	51.6%	32.8%	15.1%	34.0%

Another study published in 2002 and conducted by the National Academy of Sciences over a 3-year period concluded: “There is no clear and consistent association between increased intakes of added sugars and BMI.” (BMI or "body-mass Index" measures body-weight and height.)

Gout

Researchers have implicated sugary drinks high in fructose in a surge in cases of the painful joint-disease gout.[12]

United Nations nutritional advice

In 2003, four United Nations agencies, (including the World Health Organization (WHO) and the Food and Agriculture Organization (FAO)) commissioned a report compiled by a panel of 30 international experts. The panel stated that the total of free sugars (all monosaccharides and disaccharides added to

foods by manufacturers, cooks or consumers, plus sugars naturally present in honey, syrups and fruit juices) should not account for more than 10% of the energy intake of a healthy diet, while carbohydrates in total should represent between 55% and 75% of the energy-intake.[13]

Debate on extrinsic sugar

Argument continues as to the value of extrinsic sugar (sugar added to food) compared to that of intrinsic sugar (naturally present in food). Adding sugar to food particularly enhances taste, but does increase the total number of calories, among other negative effects on health and physiology.

In the United States of America, sugar has become increasingly evident in food products, as more food-manufacturers add sugar or high-fructose corn-syrup to a wide variety of consumables. Candy-bars, soft drinks, chips, snacks, fruit-juice, peanut-butter, soups, ice-cream, jams, jellies, yogurt, and many breads have added sugars. Five Alive, for example, portrayed by its suppliers as "all natural" and featuring pictures of five different types of fruit on its label, comprises only 41% fruit juice, having high-fructose corn-syrup as its prime ingredient.

Many doctors argue that health authorities should classify sugar and high-fructose corn-syrup as food additives.[14] A few MDs go so far as to call refined sugar a poison.[15]

The anthropologist and dentist Weston A. Price, writing in 1939,[16] correlated the use of refined sugar (and refined grains) with malnutrition in pregnant women, malformation of the palate and jaw in their children, followed by cramping of teeth in adolescence (leading to crooked teeth and the removal of wisdom teeth molars). Price correlated other ailments and the impaired function of the pituitary or master gland with consumption of refined sugar, as well as rates of infant mortality, subnormal intelligence, delinquency, and incarceration. He also correlated the underdevelopment of the pelvis, which in women would lead to complications (pain, death, etc.) in childbirth.

Virtually all of these symptoms became the norm in modern populations consuming typical amounts of refined sugar and other "modern foods of commerce". Besides the rotting of teeth, interruptible or resumable merely by removing or re-introducing white sugar into a diet, the correlations with consumption of refined sugar may relate less to the consumption of refined sugar itself than to the absence of the consumption of "nourishment", a category in which Price did not include refined sugar.

A United Nations study[17] directly creates a definition that includes *all* extrinsic sugars and separates them completely from *intrinsic* sugars, labeling them directly as a cause of obesity and of other preventable chronic diseases.

Concerns of vegetarians and vegans

The sugar-refining industry often uses bone-char (calcinated animal bones) for decolorizing.[18] This concerns vegans and vegetarians; about a quarter of the sugar in the U.S. gets processed using bone-char as a filter and the rest gets processed with activated carbon. As bone-char does not get into the sugar, the relevant authorities consider sugar processed this way as parve/kosher.

Vegetarians and vegans may also object to the impact that the burning of the cane-fields (a common part of the harvesting practice) has on insects, rats, snakes, and other life residing in the fields.[19]

Production

Table sugar (sucrose) comes from plant sources. Two important sugar crops predominate: sugarcane (*Saccharum spp.*) and sugar beets (*Beta vulgaris*), in which sugar can account for 12% to 20% of the plant's dry weight. Some minor commercial sugar crops include the date palm (*Phoenix dactylifera*), sorghum (*Sorghum vulgare*), and the sugar maple (*Acer saccharum*). In the financial year 2001/2002, worldwide production of sugar amounted to 134.1 million tonnes.

Harvested sugarcane from India ready for processing.

The first production of sugar from sugar-cane took place in India. Alexander the Great's companions reported seeing "honey produced without the intervention of bees" and it remained exotic in Europe until the Arabs started cultivating it in Sicily and Spain. Only after the Crusades did it begin to rival honey as a sweetener in Europe. The Spanish began cultivating sugar-cane in the West Indies in 1506 (and in Cuba in 1523). The Portuguese first cultivated sugar-cane in Brazil in 1532.

Most cane-sugar comes from countries with warm climates, such as Brazil, India, China, Thailand, Mexico and Australia, the top sugar-producing countries in the world.[20] Brazil overshadows most countries, with roughly 30 million tonnes of cane-sugar produced in 2006, while India produced 21 million, China 11 million, and Thailand and Mexico roughly 5 million each. Viewed by region, Asia predominates in cane-sugar production, with large contributions from China, India and Thailand and other countries combining to account for 40% of global production in 2006. South America comes in second place with 32% of global production; Africa and Central America each produce 8% and Australia 5%. The United States, the Caribbean and Europe make up the remainder, with roughly 3% each.[21]

Beet-sugar comes from regions with cooler climates: northwest and eastern Europe, northern Japan, plus some areas in the United States (including California). In the northern hemisphere, the beet-growing season ends with the start of harvesting around September. Harvesting and processing continues until March in some cases. The availability of processing-plant capacity, and the weather both influence the duration of harvesting and processing - the industry can lay up harvested beet until processed, but frost-damaged beet becomes effectively unprocessable.

The European Union (EU) has become the world's second-largest sugar exporter. The Common Agricultural Policy of the EU sets maximum quotas for members' production to match supply and demand, and a price. Europe exports excess production quota (approximately 5 million tonnes in 2003). Part of this, "quota" sugar, gets subsidised from industry levies, the remainder (approximately half) sells as "C quota" sugar at market prices without subsidy. These subsidies and a high import tariff make it difficult for other countries to export to the EU states, or to compete with the Europeans on world markets.

The United States sets high sugar prices to support its producers, with the effect that many former consumers of sugar have switched to corn syrup (beverage-manufacturers) or moved out of the country (candy-makers).

The cheap prices of glucose syrups produced from wheat and corn (maize) threaten the traditional sugar

market. Used in combination with artificial sweeteners, they can allow drink-manufacturers to produce very low-cost goods.

Cane

Since the 6th century BC cane-sugar producers have crushed the harvested vegetable material from sugar-cane in order to collect and filter the juice. They then treat the liquid (often with lime (calcium oxide)) to remove impurities and then neutralize it. Boiling the juice then allows the sediment to settle to the bottom for dredging out, while the scum rises to the surface for skimming off. In cooling, the liquid crystallizes, usually in the process of stirring, to produce sugar crystals. Centrifuges usually remove the uncrystallized syrup. The producers can then either sell the resultant sugar, as is, for use; or process it further to produce lighter grades. This processing may take place in another factory in another country. Sugar cane is the fourth in the list for agriculture in china.

Beet

Sugar beets

Beet-sugar producers slice the washed beets, then extract the sugar with hot water in a "diffuser". An alkaline solution ("milk of lime" and carbon dioxide from the lime kiln) then serves to precipitate impurities (see carbonatation). After filtration, evaporation concentrates the juice to a content of about 70% solids, and controlled crystallisation extracts the sugar. A centrifuge removes the sugar crystals from the liquid, which gets recycled in the crystalliser stages. When economic constraints prevent the removal of more sugar, the manufacturer discards the remaining liquid, now known as molasses.

Sieving the resultant white sugar produces different grades for selling.

Cane versus beet

Little perceptible difference exists between sugar produced from beet and that from cane. Chemical tests can distinguish the two, and some tests aim to detect fraudulent abuse of European Union subsidies or to aid in the detection of adulterated fruit-juice.

The production of sugar-cane needs approximately four times as much water as the production of sugar-beet, therefore some countries that traditionally produced cane-sugar (such as Egypt) have seen the building of new beet-sugar factories recently. On the other hand, sugar cane tolerates hot climates better. Some sugar-factories process both sugar cane and sugar beets and extend their processing period in that way.

The production of sugar results in residues which differ substantially depending on the raw materials used and on the place of production. While cooks often use cane molasses in food-preparation, humans find molasses from sugar-beet unpalatable, and it therefore ends up mostly as industrial fermentation feedstock (for example in alcohol distilleries), or as animal-feed. Once dried, either type of molasses can serve as fuel for burning.

Culinary sugars

So-called **raw sugars** comprise yellow to brown sugars made by clarifying the source syrup by boiling and drying with heat, until it becomes a crystalline solid, with minimal chemical processing. Raw beet sugars result from the processing of sugar-beet juice, but only as intermediates *en route* to white sugar. Types of raw sugar include *demerara*, *muscovado*, and *turbinado*. Mauritius and Malawi export significant quantities of such specialty sugars. Manufacturers sometimes prepare raw sugar as loaves rather than as a crystalline powder, by pouring sugar and molasses together into molds and allowing the mixture to dry. This results in sugar-cakes or loaves, called *jaggery* or *gur* in India, *pingbian tang* in China, and *panela, panocha, pile, piloncillo* and *pão-de-açúcar* in various parts of Latin America. In South America, truly raw sugar, unheated and made from sugar-cane grown on farms, does not have a large market-share.

Mill white sugar, also called **plantation white, crystal sugar**, or **superior sugar**, consists of raw sugar where the production process does not remove colored impurities, but rather bleaches them white by exposure to sulfur dioxide. Though the most common form of sugar in sugarcane-growing areas, this product does not store or ship well; after a few weeks, its impurities tend to promote discoloration and clumping.

Blanco directo, a white sugar common in India and other south Asian countries, comes from precipitating many impurities out of the cane juice by using *phosphatation* — a treatment with phosphoric acid and calcium hydroxide similar to the carbonatation technique used in beet-sugar refining. In terms of sucrose purity, blanco directo is more pure than mill white, but less pure than white refined sugar.

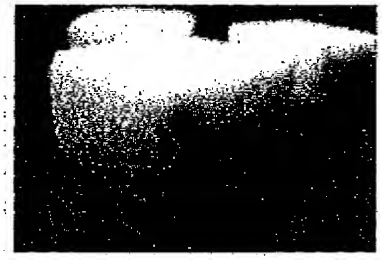
White refined sugar has become the most common form of sugar in North America as well as in Europe. Refined sugar can be made by dissolving raw sugar and purifying it with a phosphoric acid method similar to that used for blanco directo, a carbonatation process involving calcium hydroxide and carbon dioxide, or by various filtration strategies. It is then further purified by filtration through a bed of activated carbon or bone char depending on where the processing takes place. Beet sugar refineries produce refined white sugar directly without an intermediate raw stage. White refined sugar is typically sold as *granulated sugar,* which has been dried to prevent clumping.

Granulated sugar comes in various crystal sizes — for home and industrial use — depending on the application:

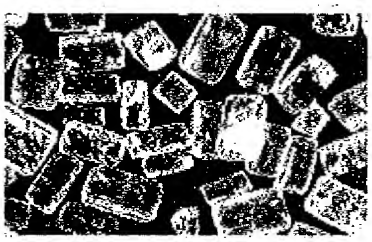
- Coarse-grained sugars, such as *sanding sugar* (also called "pearl sugar", "decorating sugar", *nibbed sugar* or *sugar nibs*) adds "sparkle" and flavor for decorating to baked goods, candies, cookies/biscuits and other desserts. The sparkling effect occurs because the sugar forms large crystals which reflect light. Sanding sugar, a large-crystal sugar, serves for making edible decorations. It has larger granules that sparkle when sprinkled on baked goods and candies and will not dissolve when subjected to heat.
- Normal granulated sugars for table use: typically they have a grain size about 0.5 mm across
- Finer grades result from selectively sieving the granulated sugar
    - *caster* (or *castor*[22]) (0.35 mm), commonly used in baking
    - *superfine* sugar, also called *baker's sugar, berry sugar*, or *bar sugar* — favored for sweetening drinks or for preparing meringue
- Finest grades
    - *Powdered sugar, 10X sugar, confectioner's sugar* (0.060 mm), or *icing sugar* (0.024 mm),

produced by grinding sugar to a fine powder. The manufacturer may add a small amount of anti-caking agent to prevent clumping — either cornstarch (1% to 3%) or tri-calcium phosphate.

Retailers also sell **sugar cubes** or lumps for convenient consumption of a standardised amount. Suppliers of sugar-cubes make them by mixing sugar crystals with sugar syrup. Jakub Kryštof Rad invented sugar-cubes in 1841.



Sugar-cubes close-up.



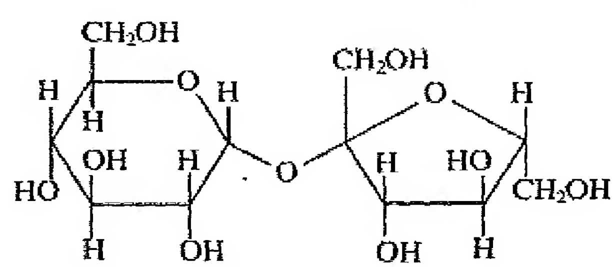
Brown sugar crystals.

Brown sugars come from the late stages of sugar refining, when sugar forms fine crystals with significant molasses-content, or from coating white refined sugar with a cane molasses syrup. Their color and taste become stronger with increasing molasses-content, as do their moisture-retaining properties. Brown sugars also tend to harden if exposed to the atmosphere, although proper handling can reverse this.

The World Health Organisation and the Food and Agriculture Organization of the United Nations expert report (WHO Technical Report Series 916 Diet, Nutrition and the Prevention of Chronic Diseases) defines **free sugars** as all monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups and fruit-juices. This includes all the sugars referred to above. The term distinguishes these forms from all other *culinary sugars* added in their natural form with no refining at all.

Natural sugars comprise all completely unrefined sugars: effectively all sugars not defined as *free sugars*. The WHO Technical Report Series 916 Diet, Nutrition and the Prevention of Chronic Diseases approves only natural sugars as carbohydrates for unrestricted consumption. Natural sugars come in fruit, grains and vegetables in their natural or cooked form.

Chemistry



Sucrose: a disaccharide of glucose (left) and fructose (right), important molecules in the body.

Biochemists regard sugars as relatively simple carbohydrates. Sugars include monosaccharides, disaccharides, trisaccharides and the oligosaccharides - containing 1, 2, 3, and 4 or more monosaccharide units respectively. Sugars contain either aldehyde groups (-CHO) or ketone groups (C=O), where there are carbon-oxygen double bonds, making the sugars reactive. Most simple sugars (monosaccharides) conform to $(CH_2O)_n$ where n is between 3 and 7. A notable exception, deoxyribose, as its name suggests, has a "missing" oxygen atom. All saccharides with more than one ring in their structure result from two or more monosaccharides joined by glycosidic bonds with the resultant loss of a molecule of water (H_2O) per bond.

As well as using classifications based on their reactive group, chemists may also subdivide sugars according to the number of carbons they contain. Derivatives of trioses ($C_3H_6O_3$) are intermediates in glycolysis. Pentoses (5-carbon sugars) include ribose and deoxyribose, which form part of nucleic acids. Ribose also forms a component of several chemicals that have importance in the metabolic process, including NADH and ATP. Hexoses (6-carbon sugars) include glucose, a universal substrate for the production of energy in the form of ATP. Through photosynthesis plants produce glucose, which has the formula $C_6H_{12}O_6$, and then convert it for storage as an energy-reserve in the form of other carbohydrates such as starch, or (as in cane and beet) as sucrose (table sugar). Sucrose has the chemical formula $C_{12}H_{22}O_{11}$.

Many pentoses and hexoses can form ring structures. In these closed-chain forms, the aldehyde or ketone group remains unfree, so many of the reactions typical of these groups cannot occur. Glucose in solution exists mostly in the ring form at equilibrium, with less than 0.1% of the molecules in the open-chain form.

Monosaccharides in a closed-chain form can form glycosidic bonds with other monosaccharides, creating disaccharides (such as sucrose) and polysaccharides (such as starch). Enzymes must hydrolyse or otherwise break these glycosidic bonds before such compounds become metabolised. After digestion and absorption. the principal monosaccharides present in the blood and internal tissues include glucose, fructose, and galactose.

The prefix "glyco-" indicates the presence of a sugar in an otherwise non-carbohydrate substance. Note for example glycoproteins, proteins connected to one or more sugars.

Monosaccharides include fructose, glucose, galactose and mannose. Disaccharides occur most commonly as sucrose (cane or beet sugar - made from one glucose and one fructose), lactose (milk sugar - made from one glucose and one galactose) and maltose (made of two glucoses). These disaccharides have the formula $C_{12}H_{22}O_{11}$.

Hydrolysis can convert sucrose into a syrup of fructose and glucose, producing *invert sugar*. This resulting syrup, sweeter than the original sucrose,[23] has uses in making confections because it does not crystallize as easily and thus produces a smoother finished product.

If combined with fine ash, sugar will burn with a blue flame.

Measuring sugar

See also International Commission for Uniform Methods of Sugar Analysis

Dissolved sugar content

Scientists and the sugar industry use degrees Brix (symbol °Bx), introduced by Antoine Brix, as units of measurement of the mass ratio of dissolved substance to water in a liquid. A 25 °Bx sucrose solution has 25 grams of sucrose per 100 grams of liquid; or, to put it another way, 25 grams of sucrose sugar and 75 grams of water exist in the 100 grams of solution.

An infrared Brix sensor measures the vibrational frequency of the sugar molecules, giving a Brix

degrees measurement. This does not equate to Brix degrees from a density or refractive index measurement because it will specifically measure dissolved sugar concentration instead of all dissolved solids. When using a refractometer, one should report the result as "refractometric dried substance" (RDS). One might speak of a liquid as having 20 °Bx RDS. This refers to a measure of percent by weight of *total* dried solids and, although not technically the same as Brix degrees determined through an infrared method, renders an accurate measurement of sucrose content, since sucrose in fact forms the majority of dried solids. The advent of in-line infrared Brix measurement sensors has made measuring the amount of dissolved sugar in products economical using a direct measurement.

Purity

Technicians usually measure the purity (sucrose content) of sugar by polarimetry — the measurement of the rotation of plane-polarized light by a solution of sugar.

Baking weight/mass volume relationship

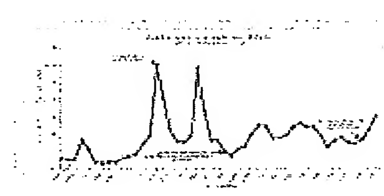
Different culinary sugar have different densities due to differences in particle size and inclusion of moisture.[24] E.g.

- Granular sugar 1 cup = 200g = 7 oz
- Powdered sugar 1 cup = 100g = 3.5 oz
- Brown sugar 1 cup = 220g = 7.8 oz

Trade and economics

Historically one of the most widely-traded commodities in the world, sugar accounts for around 2% of the global dry cargo market. International sugar prices show great volatility, ranging from around 3 to over 60 cents per pound in the past 50 years. Of the world's 180-odd countries, around 100 produce sugar from beet or cane, a few more refine raw sugar to produce white sugar, and all countries consume sugar. Consumption of sugar ranges from around 3 kilograms per person per annum in Ethiopia to around 40 kg/person/yr in Belgium. Consumption per capita rises with income per capita until it reaches a plateau of around 35kg per person per year in middle-income countries.

Many countries subsidize sugar-production heavily. The European Union, the United States, Japan and many developing countries subsidize domestic production and maintain high tariffs on imports. Sugar prices in these countries have often exceeded prices on the international market by up to three times; today, with world market sugar futures prices currently strong, such prices typically exceed world prices by two times.



World raw-sugar price for the calendar years 1960 to 2006.

Within international trade bodies, especially in the World Trade Organization, the "G20" countries led by Brazil have long argued that because these sugar markets essentially exclude cane-sugar imports, the G20 sugar-producers receive lower prices than they would under free trade. While both the European Union and United States maintain trade agreements whereby certain developing and less-developed countries (LDCs) can sell certain quantities of sugar into their markets, free of the usual import tariffs, countries outside these preferred trade régimes have complained

that these arrangements violate the "most favoured nation" principle of international trade. This has led to numerous tariffs and levies in the past.[25]

In 2004, the WTO sided with a group of cane-sugar exporting nations (led by Brazil and Australia) and ruled the EU sugar-régime and the accompanying ACP-EU Sugar Protocol (whereby a group of African, Caribbean, and Pacific countries receive preferential access to the European sugar market) illegal.[26] In response to this and to other rulings of the WTO, and owing to internal pressures on the EU sugar-régime, the European Commission proposed on 22 June 2005 a radical reform of the EU sugar-régime, cutting prices by 39% and eliminating all EU sugar exports.[27] The African, Caribbean, Pacific and least developed country sugar-exporters reacted with dismay to the EU sugar proposals,[28]. On 25 November 2005 the Council of the EU agreed to cut EU sugar-prices by 36% as from 2009. It now seems[29] that the U.S. Sugar Program could become the next target for reform. However, some commentators expect heavy lobbying from the U.S. sugar-industry, which donated $2.7 million to US House and US Senate incumbents in the 2006 US election, more than any other group of US food-growers.[30] Especially prominent lobbyists include The Fanjul Brothers, so-called "sugar barons" who made the single largest individual contributions of soft money to both the Democratic and Republican parties in the political system of the United States of America.[31][32]

Small quantities of sugar, especially specialty grades of sugar, reach the market as 'fair trade' commodities; the fair-trade system produces and sells these products with the understanding that a larger-than-usual fraction of the revenue will support small farmers in the developing world. However, whilst the Fairtrade Foundation offers a premium of USD 60.00 per tonne to small farmers for sugar branded as "Fairtrade",[33] government schemes such the U.S. Sugar Program and the ACP Sugar Protocol offer premiums of around USD 400.00 per tonne above world market prices. However, the EU announced on 14 September 2007 that it would denounce the ACP Sugar Protocol with effect from 1 October 2009.[34][35]

The Sugar Association has launched a campaign to promote sugar over artificial substitutes. The Association now aggressively challenges many common beliefs regarding negative side effects of sugar consumption. The campaign aired a high-profile television-commercial during the 2007 Prime Time Emmy Awards on FOX Television. The Sugar Association uses the trademark tagline "Sugar: sweet by nature."[36]

See also

- Barley sugar
- Biobutanol
- Brown sugar
- Brix
- Caramel
- Corn syrup
- Fermentation
- Glycomics
- Golden syrup
- Holing cane
- List of unrefined sweeteners
- Maple sugar
- Natural brown sugar
- Palm sugar

- Rock candy
- Stevia
- Sugar plantations in the Caribbean
- Sugar loaf
- Sugar packet
- Sugar substitute
- The Hawaiian Vibora Luviminda trades union
- Saccharophilic pathogen

Notes

1. ^ *a b c d* Adas, Michael (January 2001). *Agricultural and Pastoral Societies in Ancient and Classical History*. Temple University Press. ISBN 1566398320. Page 311.
2. ^ *a b c* Robyt 1998: 19-21
3. ^ *a b* James 2004: 4
4. ^ *a b* Ahmad Y Hassan, Transfer Of Islamic Technology To The West, Part III: Technology Transfer in the Chemical Industries, *History of Science and Technology in Islam*.
5. ^ Compare the OED and the *Online Etymology Dictionary*.
6. ^ Tooth Decay
7. ^ What causes tooth decay?
8. ^ What I need to know about Eating and Diabetes
9. ^ What if It's All Been a Big Fat Lie? - New York Times
10. ^ WHO | Obesity and overweight
11. ^ http://www.cdc.gov/nchs/nhanes.htm National Health and Nutrition Examination Survey
12. ^ http://news.bbc.co.uk/2/hi/health/7219473.stm retrieved [2008-02-06]]
13. ^ See table 6, page 56 of the WHO Technical Report Series 916, *Diet, Nutrition and the Prevention of Chronic Diseases*: online at http://www.fao.org/docrep/005/AC911E/ac911e07.htm#bm07.1.3
14. ^ M. Linda Vahrenkamp, "Your Immune System and Refined Sugars", *Your Health Magazine*
15. ^ "Alan N. Speen, MD, "Sugar - Sweet Poison"".. Cited to document the existence of the allegation; without any endorsement of the view intended or implied.
16. ^ Weston A. Price: *Nutrition and Physical Degeneration: A Comparison of Primitive and Modern Diets and Their Effect*. Hoeber: 1939. Retrieved from http://www.journeytoforever.org/farm_library/price/pricetoc.html — 2007-07-20
17. ^ 5. Population nutrient intake goals for preventing diet-related chronic diseases
18. ^ The Great Sugar Debate: Is it Vegan?
19. ^ SKIL - How Sugar Cane Is Made
20. ^ Food and Agriculture Organization of the United Nations
21. ^ Food and Agriculture Organization of the United Nations
22. ^ The Oxford English Dictionary (OED) classifies both spellings as correct, but "castor" used to prevail.
23. ^ scientificpsychic.com
24. ^ Volume and Weight Conversions for Common Baking Ingredients
25. ^ www.americansugarcouncil.gov/info/tariffhist/history01
26. ^ http://www.wto.org/english/tratop_e/dispu_e/cases_e/1pagesum_e/ds266sum_e.pdf
27. ^ Agriculture - Sugar
28. ^ ACP Group of States - The Fiji Communiqué on Sugar
29. ^ International Sugar Trade Coalition
30. ^ *New York Times*, October 18, 2007, http://www.nytimes.com/2007/10/18/business/18sugar.html
31. ^ *New York Times*, November 11, 2003, http://www.nytimes.com/2003/11/29/opinion/29SAT1.html
32. ^ http://www.motherjones.com/news/special_reports/coinop_congress/97mojo_400/boller.html
33. ^ >> F L O >> Fairtrade Labelling Organizations International
34. ^ European Commission - External Trade - Trade Issues
35. ^ European Commission - External Trade - Trade Issues
36. ^ Sugar Association

References

- Adas, Michael (January 2001). *Agricultural and Pastoral Societies in Ancient and Classical History*. Temple University Press. ISBN 1566398320.

- Robyt, John (January 1998). *Essentials of Carbohydrate Chemistry*. Springer-Verlag New York, LLC. ISBN 0387949518.

- James, Glyn (2004). *Sugarcane*. Blackwell Publishing. ISBN 063205476X.

- A C Hannah, *The International Sugar Trade*, Cambridge: Woodhead, 1996. ISBN 1-85573-069-3

- William Dufty, *Sugar Blues*, ISBN 0-446-34312-9

External links

- "From sweet on the table to fuel in the tank: the millenary history of Sugar Cane" Retrieved 2007-10-04
- Cook's Thesaurus: Sugar
- Historical charts of NYBOT futures contracts (No.11) - from 1961
- The Hidden Story of Big Sugar
- Expert Report on diet and chronic disease (WHO/FAO)
- Harvesting Poverty: America's Sugar Daddies
- sugar at the Open Directory Project

Retrieved from "http://en.wikipedia.org/wiki/Sugar"
Categories: Sugar | Carbohydrates | Sweeteners | Nutrition | Granular materials
Hidden categories: All articles with unsourced statements | Articles with unsourced statements since October 2007 | Articles with unsourced statements since September 2007 | Articles with unsourced statements since February 2007 | Health articles needing expert attention | Articles needing expert attention | Pages needing expert attention | Articles with specifically-marked weasel-worded phrases | Articles with unsourced statements since March 2008 | Articles with unsourced statements since June 2007 | Articles with unsourced statements since August 2007 | All pages needing cleanup | Articles that may contain original research since September 2007 | Articles needing additional references from June 2007 | Articles with unsourced statements since November 2007

- This page was last modified on 28 March 2008, at 13:52.